price we paid for this in the suburbs is different than the price we paid inside. Why is that?

Well, you have to pay a transportation cost. Now, it might be a small amount, but there can be differences.

So I would say that uniformity of price is not to perfect markets, and it's certainly not necessary to the definition of a homogeneous input. I mean, I can imagine homogeneous inputs being paid at different rates at different places.

Q Would that be true across different industries?

A If there's competition, probably -- probably not. The only place I would expect to find that is in an imperfectly operating market. I mean, it's --

Q Do you consider capital and labor inputs generally to be homogeneous?

A Labor as a mass. And treated as a macro entity, and capital being treated as a macro entity, probably not.

I take a much more microeconomic approach. And so what I would do is I disaggregate -- I disaggregate the inputs down to a point where it makes sense. So I would not only want to take programmers and managers -- let me think of something else -- farmers.

Let me back up. I would not take farmers and programmers and put them in the same group. I would disaggregate them down to the point where I would say, This group is relatively homogeneous; this group is relatively homogeneous, okay? And then I would say these are my inputs. And then I would ask the question, Can I aggregate these inputs.

And there are rules for when you can aggregate inputs. For example, if the relative prices stay more or less the same, then you can aggregate them and treat them as though they were homogeneous, but you have to go through an analysis to do that. You can't, willy-nilly, say, I'm going to lump these together because that happens to be the way the accountants reported it; I'm going to lump these together because the accountants reported it that way.

That's the biggest problem economists have working with accountants; the accountants want to put things in different boxes than economists want. So we go and we make things homogeneous, and then we start from there.

So I don't believe there are nonhomogeneous inputs. There are homogeneous inputs, and then you ask questions whether you can aggregate them or not. And I think what you would call a homogeneous -- nonhomogeneous input, you might be talking about different inputs, what I would consider entirely different inputs in different markets, et cetera.

Q A few moments ago, I thought you said that you didn't understand what the term "nonhomogeneous inputs" meant. But you appear now to have a definition of it;

is that right?
A I still don't know what a nonhomogeneous -- I think what you might have meant by that was different inputs on the same -- yes.
Q Are you familiar with a professor at Amherst named Walter Nickelson?
A Yes.
Q Are you familiar with his text Microeconomic Theory?
A I remember it from some time in the past.
Q Let me read you a statement from that text and, tell me if you agree with it.
Capital -- I'm sorry; let me give you the context. He's discussing a production function for outputs --
A Okay.
Q -- where his function of the Form Q, meaning output during a particular period, is equal to a function of K, L, M, et cetera, where K is the capital, L is the labor inputs, and M is the raw materials.
A Yes.
Q Do you have that context?
A No.
Q That's a pretty basic production function; isn't it?
A Depending on how K, L, M, F and Q are defined.
Q He drops a footnote, and I'll tell you this is on page 181 of the text of Microeconomic Theory,

although I don't know which edition it is.

A The last edition I looked at was 2, and I think it's gone through some since then.

Q He drops a footnote with respect to right behind his definition of K, referring to capital, and L referring to labor, and he says, and I quote:

"Capital and labor inputs are assumed to be homogeneous. This is a great simplification since there are, in reality, numerous kinds of labor and many types of machines. The recognition that these inputs are in fact inhomogeneous raises many technical problems in the theory of aggregation."

Do you agree with that statement?

A No, I don't. I can tell you why.

Q I don't want to know why.

A All right.

Q I want to know if you agree.

A (No Response)

Q Now, would you agree similarly if I asked you before that the degree of homogeneity among inputs is an empirical question?

A The degree of homogeneity among inputs is an emperical question between -- measured how?

Q Well, let's start by measuring them as to their availability across different industries.

A So if cars and computers are equally available, then they're homogeneous?
Q No.
A Okay.
Q That's not my point. The question goes to whether a particular input is homogeneous across different industries. And I'm asking you whether the degree of that homogeneity is an empirical question.
A If it's a particular input, the way I look at it is by definition of homogeneous. So if you're talking about an input, that says to me a homogeneous -- that one of them looks exactly the same as the other.
Q Would you agree that different industries by their very nature use different mixes of inputs?
A Some industries use different mixtures of inputs, yes.
Q Certain industries for example could be identified as labor intensive; is that right?
A People have tried in simple cases to talk about labor intensity or capital intensity by defining a group of inputs as labor and a group of inputs as capital, and somebody decides, Well, this is really energy.
And so they say, We'll pull that out; this really isn't mature; we'll pull that out.
Yes, people try to do that. I'm not a particular fan of doing that except to illustrate things in principal courses where to say, Just assume it's a

paper clip, and it's the only capital and there are people working in this particular job, and jobs of this particular type are the only input -- the only labor input, then it's relatively easy to talk about capital and labor intensities. In general, I don't like to do that.

Q Would you agree that the health care industry is more labor intensive than the telecommunications industry?

A I don't know. I'd have to look at an input/output table, and then we'd have to decide which was labor, which was capital and all those -- those things.

Q Well, given your dislike of analyzing capital and labor intensities, is it true that you're at least familiar with the fact that some people have tried to make these comparisons?

A Oh, yes.

Q In your review of those comparisons, can you identify any particular industry that stands out in your mind as one that has been identified as being more labor intensive than most?

A Off the top of my head, no.

Q How about one that is more capital intensive than most?

A Not off the top of my head.

Q Dr. Duncan, have you ever performed a total factor productivity yourself?

A Yes, I have.

Q Can you tell us real briefly what goes into such a study?

A Well, it depends on which approach you take.

I usually start from a cost function. You decompose the cost function into a -- you're asking the question, How does the cost function change. So you want to know -- you want to get an idea of what the productivity is.

And one way of measuring productivity would be to say, How does the cost function change.

The cost function is the minimum cost of producing a certain level of output when input prices are fixed at certain levels. And so then you say, Over time, outputs change, prices change and the technology changes, and we would like to break the change in the cost up into these components: A component due to output, a component due to the change in input prices, and anything else that's left over is usually assigned to the change in technology, okay?

And so then you do that decomposition, and you write down the mathematics, and it suggests that you have to go in and look for variables, price factors, shares, outputs.

In the case where you have many outputs, things get a little messy, and people use output indices.

In the case of where there's one output, it's

A You need data on outputs, data on input prices, data on cost shares, and that's a fraction of the input, the expenditure on that input, relative to total cost.

If you have multi outputs, you usually are going to revenue-share weight the outputs. So then you need revenue shares. So you need the percentage of revenue from that particular input as a total amount. And you need the change in costs themselves.

And under competition, you can get away with some of these -- you can get away with not having some of these things because certain things cancel out. So, for example, if you have perfect competition and you have zero profits, that allows you to get away from having certain variables. But by and large, that's what you need, and you need to know the time period involved.

Q That's a critical element of a productivity study, isn't it, the time period?

A Well, it's not critical. It's just that if you do a total factor productivity analysis -- and let's be a little careful, when I say time period, I'm talking about, Are you going to be working with annual data versus monthly data versus daily data.

I mean, you could conceivably do daily total factor productivity, and people would look at you and say that they're going to be unstable and terrible and hard to do; and nobody cares.

So usually you look at monthly or annual, and

that depends upon the availability of data quite often.
Q There's another meaning of time period, and that is, you have to determine what period of time over which you're going to measure the productivity; isn't that right?
A Well, I suppose so.
Q You mentioned that you need to know input prices. Are you trying to determine how input prices have changed over a period of time in connection with this study?
A You need to have some information on the input prices, yes.
Q What I'm asking is, do you need it as of a particular snapshot period of time, or do you need it over a period so you can compare input price growth, for example?
A You need the inputs that enter -- you need prices for inputs that enter that particular production process.
Q Well, Dr. Christensen, for example, in his study used as one of his inputs the capital, correct?
A That's correct.
Q And he provided a 1984 base value for capital for each of the LECs; isn't that right?
A I believe so.
Q And then he showed the annual growth rate in that capital from 1984 to 1992; isn't that right?
A I'm going to have to check it. Can you -- I

mean, I'm not --

Q Well, let me show you Exhibit 6, which is Dr. Christensen's direct testimony.

A I may have that here if you refer me to the page.

Q All right. Actually, it might be helpful if you look also at Exhibit 9, which is the USTA ex parte notice which showed his updated data, if you have that as well.

MR. GOLABEK: I don't believe that he has it. He may have that.

MR. FABER: Well, I have a copy of it.

Q Would you like to look at mine?

A Sure.

MR. FABER: Can I give this to the witness, your Honor?

MR. GOLABEK: Okay. He may have it, but I just don't know for sure.

MR. FABER: Q Look, if you would -- maybe to simplify this, Dr. Duncan -- at Exhibit 9 on the fourth page.

A Which says page 4 but is really page 3?

Q Well, mine doesn't even have a page number so --

A Up at the top it says page 4 of 28.

Q No. I want you to look at the next page.

A The one that says Christensen LEC TFP Study.

Q Composite Corrected?

A Right.
Q Do you see there that in that composite, he shows the 1984 gross capital stock; is that right?
A Yes.
Q And that's for all of the LECs as a group?
A I don't know.
Q I thought you told us that you were fairly familiar with Dr. Christensen's study?
A I am in large measure familiar with it. I reviewed it. But on a detail like this, I'd have to go back and check and read.
I wouldn't want to just assert that, because it says LEC, that in fact these are all of the LECs or --
Q Okay.
A -- or, you know, 90 percent of the LECs or what fraction of the LECs they are. I just don't know.
Q Well, let me go back to the preliminary question which is, in performing a productivity study of the LEC industry, isn't it correct that you would want to analyze the input price growth affecting that industry? ]
A The changes in the input prices are an important component of the TFP, yes.
Q Now, I use the words -- word "growth."
It could be decline. Is that what you're implying?
We're talking about changes in input prices.

A I guess the only thing I'm struggling with here is the input prices do enter the TFP. But, if I'm listening to you right, you're treating them as kind of an aggregate, and they actually enter individually; and what you would like to have is the individual prices, and then ask the questions again about aggregation -- do these aggregate nicely or don't they aggregate nicely -- and if they don't aggregate nicely, then you can't use them.

Q I didn't mean to aggregate them at all.

I'm perfectly happy to ask the question the way you've just put it.

A Okay.

Q That is, the individual input price growth for each of the participants in the study is an important element in that study.

A Yes.

Q Now, suppose that you were going to do, yourself, a study of the Total Factor Productivity of the seven regional Bell Operating Companies.

A Okay.

Q How would you go about gathering the data?

And let's assume for a moment that there's no problems with proprietary objections to giving it to you.

A Well, I guess I would start with the outputs.

And I would get output measures. I would get -- I think I probably wouldn't take a cost-function approach to this because it's multi-product. This is complicated.

I would probably take a more standard production-function approach.

So, then, in that case, you look at what's called the transformation function, and you ask the question: How does this change as a function of input price -- of not input-price changes but input changes, output changes, and technology.

I would try to estimate a production function and see how the production function changed over time. So I would take a -- so if I were doing it, I would take an econometric approach, estimate a multi-product production function, decompose the production function into the changes due to out -- change necessary outputs -- parts due to changes in the inputs themselves, and the parts due to changes in technology -- and then ask how has that change in technology -- how -- or how has that effect of technology changed over time.

So this is if I could get all the data I wanted. That's how I would go about doing it --

Q Why, briefly, would you do the production-function method instead of the cost-function method?

A Because I find that it's harder to get at the data, or at least I find it harder to get at the data, from the cost-function approach.

They should turn out to be more or less the same thing.

But if I had a choice -- and it's probably just a preference -- I prefer to work with the production function rather than the cost functions --

Q What method did Dr. Christensen use in his study?

A He used a nonparametric approach, which is a third approach where you can write down the differences, and then you can kind of pick and choose, depending upon what the market assumptions are, so that whatever data are available, can you say, Well, you know, if we were taking the pure cost-function approach, we would do it this way; and if we were doing the pure cost production-function approach, we'd do it this way.

Well, you never have the right data for a pure production-function approach and you never have the right data for a pure cost-function approach. So there are a bunch of -- they're called -- dual forms, and so you can do partially production function, partially cost function, all right, and then what you can do is you can say, Okay, we wanted to do this, but we didn't have these data, but here's a dual form that says if you don't have this and this is true, then you can use this.

Now -- and that's pretty much what Dr. Christensen did, is form his -- one of the many dual forms that come from either the production- or the cost-function approach.

These all are more or less equivalent under assumptions of perfect competition, et cetera, et cetera, et cetera.

If you don't have that, then there are some differences. But they're not usually very extreme.

And in the case we're faced with here, there really aren't alternatives because you can't go and get the other data.

MR. FABER: May we go off the record for a moment, your Honor?

ALJ REED: Off the record

(Off the record)

ALJ REED: On the record.

MR. FABER: Q I just want to make clear, Dr. Duncan, you mentioned originally, when I asked you how you would perform a productivity study, that you might use a cost-function methodology, and then you said, but because the complexity of the multi-product nature of the RBOC industry that you would probably use a production-function industry.

You never mentioned a nonparametric method until I asked you what Dr. Christensen did.

Is it not something that you would normally use?

A The way you do a Total Factor Productivity analysis, unfortunately, is dictated on the available data and, whereas, for teaching Total Factor

Productivity, I find it useful to talk about the cost-function approach.

And I don't think I said I would use a cost function.

I said in terms of explaining what Total Factor Productivity is, I think talking about cost functions is useful.

For doing them myself, if I can have the data, I would prefer the production-function approach.

But, in point of fact, when you get out in the world, you don't know what data you're going to have available to you, you don't know if people have kept the information.

They didn't know they were going to do a Total Factor Productivity, you know, X number of years. So you go and you say, What data do we have available? What data series do we have available?

Are we going to be able to do an analysis with it?

Are we going to have to correct any of these data?

Are we going to have to, you know, go and say, Well, look, you know, there's a problem here. You know, these are aggregated together. They shouldn't be, you know. What should we do?

There are a whole array of things that somebody needs to do to do a Total Factor Productivity study.

And, depending upon what the data are going to look like, one would pick cost-function approach, production-function approach, some -- and when I say intermediate approach, I mean I view these as all -- they all give the same results under assumptions. Though the -- the ones that Dr. Christensen used would not be the ones you would want to start first-year graduate students out on.

You'd want to start them out with the cost function.

So that's really the reason I did it that way, is trying to enlighten them, not to obfuscate things.

Q Back to the question about performing the study of the RBOCs.

I specifically asked you how you would gather the data, and what I meant by that is would you go to records of data that you have in your own files or would you go to the RBOCs and ask them to produce data to you?

A Well, if I was doing it for the RBOCs, I would go to them.

Q You would need to get information from them, from their own internal records; is that right?

A Well, either that, or we'd get some of this information from Form M. And they report stuff like this to the Bureau of Labor Statistics.

I mean there's lots of reporting that's done, and I would probably go there first and see what was reported publicly.

Q Would you expect that you could gather enough data from public filings to perform the entire study?

A Except for the revenue shares, probably.

Maybe even for the revenue share.

I mean I -- it would have to be the case that -- that if you were going to do something like that, even from the publicly available data, you'd have to check with the companies, I would think.

Q Like you, Dr. Christensen used a technical term, he called it a sanity check.

A That's right.

Q What would you do to test the accuracy of the data that you had obtained either through public documents or from the RBOCs?

A Well, the first thing I would do, and the first thing I always do before I do an empirical study, is to see if somebody else has done it, and, if somebody else has done it, to see if I need to do one. Because these things are costly.

So the first thing I would do is I would go and see if somebody else had already done the analysis. And if they had, I would, you know, look through it, see if it looked good, and probably just say Use that.

Now, let's say I'm doing the analysis because there's some difference on updating or something like that. I guess one of the things I would do is I'd say, Well, we have this information on the industry up to

some point. I'll use that as my sanity test.
And so if I found a Total Factor Productivity of, you know, two for 50 years and then suddenly I found a total factor productivity of, you know, minus 12, I would start saying, well, you know, I think there might be something wrong here.
Q If -- let's assume that you're doing the analysis, not to update and not in the situation where someone else had done the analysis?
A You're the first person ever doing this analysis.
Q Yes.
A Okay.
Q Is it correct that that's what Dr. Christensen was doing with respect to the LECs?
A That he was doing it for the first time?
Q Yes.
A No. I think -- I think there are other -- in fact, I know there are other TFP studies around other than his.
Q Well, let's assume for the sake of my question that you're doing it for the first time.
A All right.
Q And you go to the Form M's and other public documents and you gather data on inputs and cost shares and revenue shares, changes in costs -- whatever is available in that material -- and you either decide that that's enough or you need more, in which case you go to

the LECs directly and say, Give me some more.

A Okay.

Q Having completed that process, you now have a whole pile of data in front of you --

A Okay.

Q -- and you begin to perform your analysis.

A Okay.

Q Do you assume, in performing your analysis, that the data in front of you that you gathered from all of those sources has been reported accurately?

A Yeah, I generally do. If I've talked to them and -- and, you know, at some point you have to say, you know, I trust the people I'm getting the data from.

I mean you can't get down there and figure out what that accountant in Account 1932 was doing when he was entering that stuff in the ledger nor can you go back to 1964 when they computerized it the first time nor any of those things.

At some point you have to say, I assume that this is correct, by asking them by and large the procedure, you know: Did you follow this procedure? And, if they did, then you say, Well, that satisfies me.

Q So you would ask specifically how the data was gathered by the LEC.

A Yes.

Q If you were looking at Form M's, you would want to have an understanding of how the data that appears in the Form M was collected and put into that report; isn't that right?

A Yes.

I assume, though, in that particular regard, that those numbers are reported in a consistent fashion across the firm. So I wouldn't worry as much about that.

In fact, I probably wouldn't inquire much more than say in general, What are these things?

Do they mean the same thing to the accountants that they mean to the economists?

And, if they do, I wouldn't further go and see whether one firm differed, you know, greatly from another.

I wouldn't call them up and say, Well, did you really do what you say you did for Form M. I'd take it as given.

Q And so it's important to you that they reported that information in a consistent manner; is that right?

A Yes.

Q Now, would you agree that in the RBOC study we've been discussing, it would be possible that one or more of the RBOCs would provide you with inaccurate data?

A This is on Form M?

Q No. Information provided to you by the RBOCs.

A And I'm going to be talking to them about this.

Q Absolutely.

A I wouldn't think that they would be able to do that.

Q Are you aware that Dr. Christensen had to update his study because he had been given inaccurate data?

A I know he had to update his study. I didn't know it was inaccurate.

I mean under -- understand that data do change. People find -- particularly with accounting data, the booking problem, for example, is just ridiculous.

You know, suddenly you'll be told something that happened a year ago just got booked. All right. And you say, Well, what is this big blip here?

They go, Oh, well, that's the payment we got after the judgment such and such.

And I go, Well, shouldn't that go back in, you know, 1992?

They'll say, Okay, if you want to do that.

And so that kind of stuff happens all the time, the booking of revenue, you know, when the -- when the things are paid. You know, you don't say, Now, did you pay this the same year that you put it on the books and that sort of thing? Those kinds of things cause updates in data, whereas things get booked, they'll go back and say, Okay, this is booked that way.

So those kinds of things change.
I wouldn't call those inaccuracies because those are updating data. Because firms, just like people sometimes pay their bills late.
Q Let me give you some of the things that Dr. Christensen reported in his update.
For example, with Ameritech, on their gross stock item, it says:

"In the original study a reclassification of asset accounts in IOT was missed. It was corrected in the review of data for the 1993 Study."

Is that what you're talking about missing reclassifications?
A What's the IOT?
Q I have no idea. This isn't my study. It's Dr. Christensen's.
You're not familiar enough with his study to know what he's referring to as IOT?
A This is in the --
Q This is in Exhibit 9, page 2.
A Page 2.
And I'm looking for which company here?
Q Ameritech gross stock. It's the first entry on that page.
A Oh, I'm sorry.
Q Yes. Please don't use the numbers at the

top.

A Okay. So --

Q Is that the kind of updating data that you're referring to?

A Right. Right.

There are errors, there are corrections, there are -- and corrections in two senses: Correcting of errors and saying, Well, this was really -- this used to be this classification, now it's this classification, and we missed that; or This was booked now, it should have been booked two years ago.

Q Look at the bottom of that page, BellSouth Billed Revenues.

It says:

> "Input and clerical errors were made in both intrastate access revenues and long distance billed revenue in the original study."

Do you see that?

A Yes.

Q And you understand, do you, that Dr. Christensen in his update corrected for these input and clerical errors?

A That's my understanding.

Q And my question to you a moment ago was: Would you agree that in the RBOC study we were discussing, it would be possible for you to receive inaccurate data from one or more of the LECs?